

Debate: Weather Generators vs Downscaling

CEVE 543 - Fall 2025

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2025-11-17

Objective

To prepare for our in-class debate, use this document to organize your thoughts. You will be assigned to one of two “consulting firms” and must pitch your assigned model to a “City Council” as the best tool for a critical infrastructure project. Prepare your arguments for both sides. You will not know which firm you are assigned to until class begins.

The Case Study

The client is a city in the Sierra Nevada foothills. The project is designing a new, multi-billion dollar stormwater drainage and reservoir system. The engineers are worried about two specific climate scenarios that could cause catastrophic failure:

1. Failure Mode 1: The system failing after a long (e.g., 5-7 day) period of persistent, moderate rain that saturates the soil.
2. Failure Mode 2: The system failing because a very intense, but small-scale, convective storm (thunderstorm) “parks” over a single critical sub-watershed.

The “Consulting Firms”

Firm A: “Process-Informed Solutions”

Your product is the Stochastic Weather Generator described in S. Steinschneider, P. Ray, S. H. Rahat, and J. Kucharski [1]. Your philosophy: We build models from the “bottom-up” based on known physical processes (weather regimes, HMMs, thermodynamics). We do not trust GCMs. Our models are tools for exploring sensitivity and “what-if” storylines.

Firm B: “Data-Driven Analytics”

Your product is the T. Vandal, E. Kodra, S. Ganguly, A. Michaelis, R. Nemani, and A. R. Ganguly [2] deep learning downscaling model. Your philosophy: We build models that learn complex patterns from data.

Part 1: Your “Pitch”

Prepare arguments for your assigned firm. Since you don’t know which firm you’ll represent, prepare both!

Firm A Prep

Your “Elevator Pitch” (1-2 sentences)

Why is your “process-informed” model the safest, most responsible choice for this multi-billion dollar project?

Handling Failure Mode 1

This is your strength. Explain why your model (specifically, the HMM component) is the perfect tool to evaluate this risk.

Handling Failure Mode 2

This is your weakness. First, state the weakness honestly (e.g., “Our model is point-based and does not explicitly model spatial patterns...”). Now, defend it. How will you mitigate this? For example: “We would pair this with a spatial disaggregator...” or “The temporal risk is the true driver of failure, and our competitors miss it completely...”.

Firm B Prep

Your “Elevator Pitch” (1-2 sentences)

Why is your “data-driven” model the most advanced and spatially realistic choice for this project?

Handling Failure Mode 2

This is your strength. Explain why your model (specifically, the CNN’s “image processing” ability) is the only tool that can realistically capture this risk.

Handling Failure Mode 1

This is your weakness. First, state the weakness honestly (e.g., “Our model treats each day as a separate ‘image’ and has no explicit ‘memory’...”). Now, defend it. How will you mitigate this? For example: “The GCM’s low-res input provides the temporal sequence...” or “We can use a post-processing temporal model...” or “We can train a spatio-temporal version of the model, like a ConvLSTM...”.

Part 2: “Cross-Examination”

Prepare questions for the other team. Write 2-3 “tough” questions for your opponent.

Example questions:

- “Your model is point-based. How can you possibly claim to protect us from a spatial storm event? Aren’t you just ignoring the biggest risk?”
- “Your model is a ‘sensitivity’ tool where the user ‘turns the knobs.’ How is that a projection? Aren’t you just making up a future instead of forecasting one?”

Questions for Firm B (Vandal)

Example questions:

- “Your model is a ‘black box.’ You can’t even explain why it gets an answer. How can we bet billions of dollars on a model no one understands?”
- “Your model’s core assumption is ‘stationarity’—that the relationship between GCMs and reality is fixed. Isn’t that assumption guaranteed to fail in a changing climate, leaving us vulnerable?”

Preparing for Class

Before class on 11/17, complete your prep for both firms. Think carefully about:

1. The fundamental trade-offs between process-based and data-driven approaches
2. How you would honestly acknowledge your model's limitations while still making a compelling case
3. The types of questions that would expose the weaknesses of each approach

During class, you will be randomly assigned to a firm and must present your arguments to the "City Council" (your classmates and instructor).

References

Bibliography

- [1] S. Steinschneider, P. Ray, S. H. Rahat, and J. Kucharski, "A Weather-Regime-Based Stochastic Weather Generator for Climate Vulnerability Assessments of Water Systems in the Western United States," *Water Resources Research*, vol. 55, no. 8, pp. 6923–6945, 2019, doi: 10.1029/2018WR024446.
- [2] T. Vandal, E. Kodra, S. Ganguly, A. Michaelis, R. Nemani, and A. R. Ganguly, "DeepSD: Generating High Resolution Climate Change Projections through Single Image Super-Resolution." Accessed: Sep. 26, 2024. [Online]. Available: <http://arxiv.org/abs/1703.03126>